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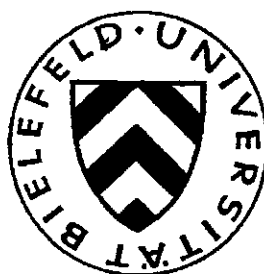
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Environmental Taxation and the Double Dividend: A Drawback for a Revenue-Neutral Tax Reform

by

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Abstract

An ecological tax reform is often believed to provide a double dividend if the revenue from green taxes is used to cut other distortionary taxes. We investigate this issue in a general-equilibrium framework with a non-competitive labor market and show that a decrease in the labor tax plausibly increases equilibrium employment without letting real profits and net wage incomes fall. The resulting positive income effect, however, causes aggregate consumption and thus pollution to rise, implying that environmental quality is lower than before. Hence, a revenue-neutral environmental tax reform aimed at achieving a double dividend is likely to be counterproductive from an environmental perspective.

Keywords: Environmental Tax, Double Dividend, Wage Bargaining

JEL Classification: E24, H23, J51, Q28

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1. Introduction

In the last years there has been an increasing interest in the question whether an ecological tax reform can yield a higher environmental quality and, simultaneously, increase non-environmental welfare. If the revenue from environmental taxes is used to cut other distortionary taxes and this allows public funds to be raised in a more efficient way, then an ecological tax reform may not only improve the environment but also enhance households' non-environmental utility. In this sense a green tax reform can provide a *double dividend*.¹

The idea that an ecological tax reform may, besides its environmental benefits, reduce the overall economic gross costs² of the tax system is politically appealing and intuitively quite convincing. revenue-neutral tax reforms suggesting that a double dividend can easily be attained by recycling the revenue from green taxes. However, recent contributions show that there are also counteracting effects that result from general-equilibrium interdependencies.³

Especially theoretical studies based on a competitive labor market deny rather than affirm the possibility of a double dividend. The common argument is as follows: If the yield from a green tax is used to cut, for example, the labor tax, this will lead to less employment as long as the higher environmental tax has an adverse effect on the real after-tax wage and the labor-supply curve is upward-bending. In this case, the green tax erodes the basis of the labor tax resulting in a higher distortion of the labor market, so that a double dividend can not be obtained.⁴

One might question, though, whether the objective of achieving a double dividend, i.e., aiming at a higher environmental quality and, simultaneously, at a higher

¹An overview of this discussion and the literature is given by GOULDER (1995).

²According to GOULDER (1995), *gross costs* denote the non-environmental welfare that has to be sacrificed in order to realize a specific environmental policy.

³These general-equilibrium effects are commonly subsumed under the notion of the 'tax-interaction effect,' e.g., by BOVENBERG AND DE MOOIJ (1994A,B), BOVENBERG AND VAN DER PLOEG (1994), LIGTHART AND VAN DER PLOEG (1997), or DE MOOIJ AND BOVENBERG (1997).

⁴cf. BOVENBERG AND DE MOOIJ (1994A,B) or BOVENBERG AND VAN DER PLOEG (1994).

level of employment, is best studied in the framework of a competitive labor market, where there is no involuntary unemployment.⁵ Most industrial countries feature labor markets that are highly monopolized, i.e., wages are determined in negotiations between trade unions and employers' associations. It, therefore, seems to be more appropriate to view the labor market as non-competitive.

Some authors have acknowledged this by assuming exogenously fixed wages or by modeling the labor market as a suppliers' market where the union dictates the wage rate. BOVENBERG AND VAN DER PLOEG (1996) investigate the occurrence of a double (or even a triple) dividend under a non-revenue-neutral, optimal tax reform, when there is involuntary unemployment. They find that employment is likely to increase when labor is a close substitute for polluting resources in production, and private consumption and leisure are poor substitutes in utility. SCHNEIDER (1997) also finds the possibility of an employment dividend in an efficiency-wage model, if the labor market is sufficiently distorted. And NIELSEN, PEDERSEN, AND SØRENSEN (1995) show how environmental policy can reduce unemployment in an endogenous-growth model in which monopolistic unions dictate wages and pollution affects production negatively. Thus, non-competitiveness of the labor market and the occurrence of (involuntary) unemployment enhances the possibility of a double dividend.

Apparently, most of the discussion concerning the double dividend concentrates on the debate over whether an environmental policy offers the additional bonus of higher employment. In the present paper, we question whether this side effect is, in fact, desirable from an ecological perspective.

In the following sections, we study the implications of a non-competitive labor market for an environmental tax reform and demonstrate that persuasive partial-equilibrium results may be incompatible when they are combined in a general-equilibrium context. We show how a revenue-neutral tax reform aimed at improving environmental quality can easily backfire: While employment increases, aggregate pollution is intensified.

⁵This view is also expressed by NIELSEN, PEDERSEN, AND SØRENSEN (1995).

The explanation for this phenomenon is quite simple. Granted that an increase in the environmental tax causes households to substitute from 'dirty' to 'clean' consumption, this will, *ceteris paribus*, lead to a higher environmental quality. However, employment and overall income also change. When a labor market equilibrium is the outcome of negotiations between competitive firms and a labor union, a lower tax burden on wage earners plausibly makes the union more employment oriented, so that equilibrium employment rises.⁶ The resulting (aggregate) income effect is then likely to lead to higher aggregate dirty consumption, even when each individual household consumes less dirty goods. As a consequence, environmental quality turns out to be lower than before the tax reform.⁷ Hence, the double-dividend hypothesis fails, but not because the employment dividend can not be achieved, as is usually the case in the literature; in our model, the exact opposite is true: Employment rises, but the environmental dividend is lost.⁸

Our point here is not that environmental taxes are welfare reducing. In order to address this issue, one would have to specify the welfare implications of economic performance as compared to environmental quality. Neither do we suggest that en-

⁶This effect is guaranteed under a revenue-neutral tax reform as long as the government faces the increasing branch of the Laffer curve, which, from an empirical perspective, appears to be the most plausible case.

⁷For a competitive labor market, BOVENBERG AND DE MOOLIJ (1994A,B) show that an environmental tax reform benefits the environment, if households' net real wage declines and dirty consumption becomes more expensive (provided that dirty consumption is a normal good). Only when a compensated increase in the price of the dirty good is proportionately less effective in reducing dirty consumption than a compensated increase in the labor tax, environmental quality may decline under a green tax reform. This result, first derived by NG (1980), was recently emphasized by SCHÖB (1996). BOVENBERG AND VAN DER PLOEG (1996) show that an increase of the environmental quality can also be expected with a non-competitive labor market, if the environmental externality occurs at the industry level, since firms then substitute away from environmentally harmful resources towards other factors (including labor).

⁸KOSKELA AND SCHÖB (1997) suggest that, when the tax is on wasteful consumption, there may actually be a trade-off between the environmental dividend and the employment dividend. Our view is more pessimistic, however, as it indicates that a revenue-neutral tax reform does not leave the opportunity to choose between dividends.

environmental taxes are counterproductive or even ineffective. On the contrary, higher environmental taxes induce individual households to reduce their wasteful consumption, both in a partial-equilibrium framework as well as in a general-equilibrium setting. Our note of caution is directed towards environmental taxation under a revenue-neutral tax reform. The message is that a *revenue-neutral* environmental tax reform aimed at achieving a double dividend is likely to be counterproductive from an environmental point of view, since the conditions which secure the employment dividend are responsible for the loss of the environmental dividend.

The paper is organized as follows: In Section 2, we describe households, firms, and the government, and show the relationship between these sectors in a general equilibrium. Our characterization here is closely related to that of BOVENBERG AND DE MOOIJ (1994A). In Section 3, we assume that the equilibrium in the labor market is determined through negotiations between competitive firms and a labor union, which represents all laborer households. Our approach follows the tradition of McDONALD AND SOLOW (1981), but we promote the generality of our results by incorporating four qualitatively different concepts of wage bargaining discussed by CREEDY AND McDONALD (1991) (1. 'Efficient bargains' induced by an asymmetric Nash bargaining solution. 2. The 'monopolistic union,' which is able to enforce its utility maximizing wage and then lets firms determine their optimal level of employment. 3. The 'right-to-manage' approach, where the contract wage is determined by an asymmetric Nash bargaining solution, and firms optimize with respect to employment. 4. The 'insider-dominated union,' which also negotiates the wage, but is not concerned about the level of employment). In Section 4, we then analyze the consequences of a revenue-neutral tax reform where the yield from the green tax is used to cut labor taxes. Section 5 summarizes the results and concludes.

2. The Model

The economy consists of households, firms, and the government. We assume that households are all identical in their tastes, but differ with respect to their incomes. Each household's utility depends on two public goods, public consumption and en-

vironmental quality, on two private goods, which we label ‘clean’ and ‘dirty,’ and on (allocatable) time used for leisure (T). We interpret public consumption (G) as goods that are publicly provided for all households, and which ensure a minimum standard of living. Environmental quality (E) is a measure which is inversely related to the aggregate of polluting (dirty) consumption. Clean goods (C) and dirty goods (D) are imperfect substitutes that are consumed as a composite commodity of quantity $Q = q(C, D)$, where q is taken to be linear homogeneous in C and D with a declining marginal rate of substitution, thus ensuring that both are normal goods. We assume preferences to be additively separable in public and private goods (including leisure), so that we can define household utility w as

$$w(G, E, Q, T) = v(G, E) + \tilde{u}(Q, T),$$

where the sub-utility functions v and \tilde{u} are monotonically increasing, twice continuously differentiable, and concave in their arguments. For institutional reasons, households can supply only their complete allocatable time, \bar{T} , for labor, so that they are either unemployed with \bar{T} units of spare time, or they have a job with 0 units of time left for additional leisure.⁹ Moreover, households can only consume private goods if they earn some income. Consequently, unemployed households with excess time but no private consumption have a private utility $\bar{u} := \tilde{u}(0, \bar{T})$. Employed households, on the other hand, can consume private goods but have no allocatable time for leisure, so that their (private) utility is $u(Q) := \tilde{u}(Q, 0)$. Due to the fact that there are various factors that account for a disutility of working, households are only willing to give up leisure if $u(Q) > \bar{u}$. That is, there exists a reservation wage \bar{W} where households are indifferent between working and being unemployed (and able to consume only public goods).¹⁰

Since households plausibly take G and E as given, optimization of an employed

⁹Of course, a household’s actual allocatable time for leisure exceeds \bar{T} , which is simply the ‘normal’ working time of a fully employed household.

¹⁰Our characterization of households is thus closely related to that of BOVENBERG AND DE MOOIJ (1994A), with somewhat simpler assumptions. In particular, the optimization of household expenditure does not involve a labor/leisure decision. The same result can be obtained in the

household only involves the maximization of (composite) private consumption for a given income I . Clean and dirty goods are identical in their production costs and, therefore, have the same before-tax market price, which we normalize to one. When goods are used in an environmentally friendly way, they remain untaxed. However, when their consumption is harmful to the environment, they are subject to a ‘dirt’ tax t_D . Consequently, each employed household consuming private goods solves

$$\max_{C,D} Q = q(C, D) \quad \text{s.t.} \quad C + (1 + t_D)D = I,$$

yielding the Marshallian demands $C(P_D, I)$ and $D(P_D, I)$, where $P_D := 1 + t_D$.¹¹ For any given budget I , an increase in t_D implies a substitution from the dirty to the clean good; moreover, there is a negative income effect on both clean and dirty consumption. Since both goods are normal, a rise of t_D causes D to fall. As a partial-equilibrium result, the decreasing demand for dirty goods makes environmental quality rise.

It is, however, not clear how an increase in t_D affects the tax revenue of the government. Obviously, this depends on the price elasticity of the demand for dirty goods. By differentiating environmental tax revenue with respect to t_D , one obtains

$$\frac{\partial(t_D D)}{\partial t_D} = D \left[1 + \frac{\partial D}{\partial P_D} \frac{1 + t_D}{D} \frac{t_D}{1 + t_D} \right].$$

For $D > 0$, the expression above is positive if, and only if,

$$(1) \quad -\frac{\partial D}{\partial P_D} \frac{1 + t_D}{D} < \frac{1 + t_D}{t_D},$$

i.e., if the tax base does not erode too quickly, in the sense that the price elasticity of the demand for dirty goods does not exceed P_D/t_D .

BOVENBERG AND DE MOOIJ (1994A) setting if the (sub)utility of leisure and private consumption is homogeneous. Moreover, the additive separability of w ensures that, in a general-equilibrium setting, a change in environmental quality will not affect wage bargaining. This assumption is not only for analytical convenience, but also excludes unrealistic features of the model. Finally, our specification of u as a concave function of Q , which itself is a linear-homogeneous function of C and D , simplifies the analytical treatment of model, without precluding any interesting aspects.

¹¹In the following, we omit the arguments of functions whenever this does not cause confusion.

Clearly, the discussion of a revenue-neutral tax reform only makes sense if higher dirt taxes also lead to higher tax revenues. In the following, we therefore postulate a functional form for q , such that condition (1) is fulfilled.

Since q is linear homogeneous in C and D , one can separate optimal expenditures into a price index P_Q , which is linear homogeneous in prices, and the composite commodity Q , which is simply the corresponding quantity index:

$$C + (1 + t_D)D = P_Q Q .$$

The optimal consumption of private goods Q is then determined by the household's budget in units of the composite commodity, i.e.,

$$Q = \frac{I}{P_Q} .$$

We distinguish between three types of households. First, there are L fully employed laborer households whose nominal income $I = (1 - t_L)W$ is given by their wage W minus the burden of a proportional labor-income tax with a tax rate of t_L . The second group consists of $N - L$ unemployed laborer households who receive no income. The total number of laborer households is thus N , which we assume to be given. The third group of households consists of identical managers (or firm-owners) who are all employed and receive the same income. These households derive their income exclusively in the form of untaxed dividends that are paid out of profits Π from firms. In this setting, the only difference between workers and managers is their income. Since manager households are identical, we can normalize their number to unity, or simply view this group as one aggregate household.

The production sector is characterized by identical competitive firms that produce only one type of good using a technology which features constant returns to scale, thus simplifying aggregation over all firms. With labor as the only variable factor of production, aggregate profits can then be written as

$$(2) \quad \Pi(W, L) := f(L) - WL ,$$

where f is monotonically increasing, twice continuously differentiable, and strictly concave, with $f(0) = 0$. For convenience, all fixed factors are suppressed as arguments of f .

The homogeneous output affects welfare by the way that it is used. If it is consumed by households in an environmentally proper way, then it is considered to be a 'clean' good. However, its consumption can also create waste, in which case the good may be called 'dirty.' Alternatively, if the good is consumed by the government, it creates (clean) public benefits, which are available to all households.¹² Equilibrium in the goods market, therefore, implies

$$f(L) = LC_L + C_M + LD_L + D_M + G ,$$

with subscripts L and M denoting the employed worker households and the manager household, respectively.

Government consumption G is financed by the revenues from the environmental tax levied on the dirty good as well as from the tax on labor income:

$$(3) \quad G = (LD_L + D_M)t_D + WLt_L .$$

By Walras' Law, the goods market is in equilibrium if the budget constraints of households, firms, and the government are satisfied.

3. Equilibrium in the Labor Market

Central to our analysis is the description of the labor market which we model as non-competitive. In particular, we follow the literature on wage bargaining and assume that wages and employment are negotiated by firms and a labor union where the latter represents all N laborer households.

On the one side of the labor market, there is the aggregate of all firms. Their manager's real full-employment income equals Π/P_Q , and her utility of private consumption is $\tilde{u}(Q, 0) = u(\Pi/P_Q)$. By differentiating the latter with respect to employment, L , and the wage, W , one obtains the slope of the manager's indifference curves, or alternatively of the firms' iso-profit curves:

$$(4) \quad \frac{dW}{dL} = \frac{f'(L) - W}{L} .$$

¹²More generally, government consumption may feature any fixed relation between clean and dirty goods.

Since f is concave, the iso-profit curves are increasing in L until $f'(L) = W$, and decreasing afterwards. In other words, for any given real wage, the profit-maximizing level of employment is where the slope of the iso-profit curve is equal to zero. Consequently,

$$(5) \quad W = f'(L)$$

characterizes the inverse labor-demand curve of the firm, the slope of which is

$$(6) \quad \frac{dW}{dL} = f''(L) < 0.$$

On the other side of the labor market, we follow the traditional approach of McDONALD AND SOLOW (1981) and assume that the labor union of all laborer households maximizes the sum of its members' utilities, which is given by

$$U(W, L; t_L, P_Q) := L u \left(\frac{(1 - t_L)W}{P_Q} \right) + (N - L) \bar{u}.$$

For any fixed N , the union's preferences can be equivalently represented by

$$(7) \quad U(W, L; t_L, P_Q) - N\bar{u} = L \left[u \left(\frac{(1 - t_L)W}{P_Q} \right) - \bar{u} \right].$$

Differentiation of union utility U with respect to employment and the wage then yields the slope of the union's indifference curves:

$$(8) \quad \frac{dW}{dL} = - \frac{P_Q(u - \bar{u})}{(1 - t_L)Lu'} < 0.$$

The union's indifference curves are downward sloping and lie above the implicitly defined reservation wage $\bar{W} := P_Q u^{-1}(\bar{u}) / (1 - t_L)$. With this description of the labor market, one can now look at different concepts of wage determination. In the following, we discuss the four alternative labor-market models analyzed by CREEDY AND McDONALD (1991). We characterize the labor-market equilibrium extensively for the case of efficient bargains; and, instead of repeating the complete analysis, we only briefly show how the results can be adapted to alternative labor-market scenarios as well.

Efficient Bargains

We begin with the case in which a firm and the union bargain over the wage and employment. We focus on efficient agreements that lie on the ‘contract curve’ which is obtained by equating the slopes of the union’s indifference curves and the firms’ iso-profit curves given by equations (8) and (4), respectively:

$$(9) \quad \frac{P_Q}{1-t_L} \frac{u - \bar{u}}{u'} = W - f'(L).$$

Since the labor union is only interested in contracts that guarantee $u \geq \bar{u}$, equation (9) implies $W \geq f'$. The contract curve thus lies above the labor-demand curve, and it only intersects the latter where $u = \bar{u}$. Moreover, total differentiation of (9) with respect to W and L reveals that the contract curve is upward sloping.

MCDONALD AND SOLOW (1981) discuss several solution concepts that induce a specific point on the contract curve, the most popular being the Nash bargaining solution. In this case, the negotiated contract is obtained by solving

$$(10) \quad \max_{W,L} [U(W, L; t_L, P_Q) - N\bar{u}]^\mu \times \Pi(W, L)^{1-\mu} \\ = \left\{ L \left[u \left(\frac{(1-t_L)W}{P_Q} \right) - \bar{u} \right] \right\}^\mu \times \left\{ f(L) - WL \right\}^{1-\mu},$$

where the weight $\mu \in [0, 1]$ reflects the distribution of bargaining power between the union and the firm. The two first-order conditions of this optimization problem yield the contract curve, given by equation (9), and the relationship

$$(11) \quad W = \mu \frac{f(L)}{L} + (1 - \mu) f'(L),$$

which we label the ‘Nash curve.’ The Nash bargaining solution thus induces an agreement on the contract curve where the consumer real wage is equal to the weighted average of the marginal and average productivity of labor. Since the production function is strictly concave, f/L exceeds f' , implying that workers earn more than their marginal product if $\mu > 0$, i.e., if the union has any bargaining power.

Figure 1 illustrates the equilibrium on the labor market. Firms’ iso-profit curves and the union’s indifference curves are indicated by Π^i and U^i , respectively. The

labor demand curve \mathcal{L}^d intersects the iso-profit curves at their maxima, and the contract curve \mathcal{C} connects the tangency points of iso-profit and indifference curves. The labor-market equilibrium is determined by the intersection between the contract curve \mathcal{C} and the Nash curve \mathcal{N} .

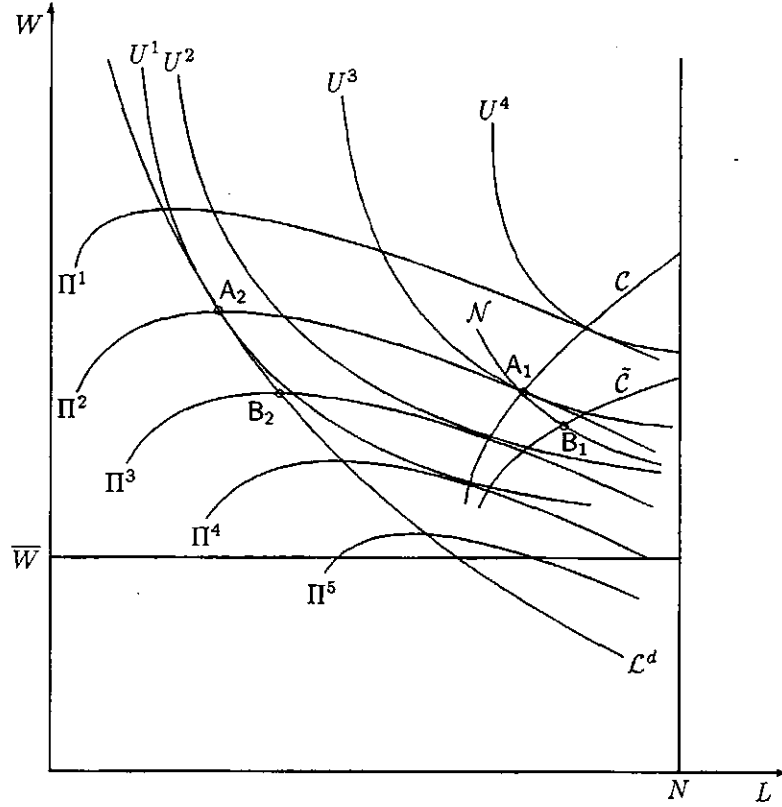


Figure 1: Contract equilibrium on the labor market

Consider now a decrease in the income tax rate t_L . Obviously, this tax policy affects the union's preferences over labor contracts. Since a decline in the labor tax, *ceteris paribus*, raises the consumer real wage, one would expect the union to become more labor oriented, i.e., in Figure 1, the indifference curves characterizing its preferences should become steeper.¹³ A change of t_L , however, has no effect on firms' profits, so that neither the labor demand curve, nor the iso-profit curves are affected. For the Nash bargaining outcome (on the contract curve), we can therefore establish the following result.

¹³The same intuition is given by NIELSEN, PEDERSEN, AND SØRENSEN (1995).

Proposition 1 *A decrease in the labor-income tax t_L , ceteris paribus, leads to an increase in employment and to a reduction in the real wage, if the labor contract is induced by a Nash bargaining solution.*

Proof: Totally differentiate the contract curve, given by equation (9), with respect to W , L , and t_L in order to obtain

$$\begin{aligned} \left[-\frac{(1-t_L)^2}{P_Q}(W-f')u'' \right] dW + [(1-t_L)u'f''] dL \\ = \left[u'f' - \frac{(1-t_L)W}{P_Q}(W-f')u'' \right] dt_L. \end{aligned}$$

With $W > f'$ along the contract curve, the coefficients of dW and dt_L are unambiguously positive, while the coefficient of dL is negative.

Total differentiation of the contract wage, given by equation (11), yields

$$dW = \left[\mu \frac{f'L - f}{L^2} + (1-\mu)f'' \right] dL.$$

This implies a negative relationship between the contract wage and contract employment, since $f'L < f$. By combining the two preceding equations, one can easily see that a lower value of t_L leads to a higher level of L and a lower level of W . \square

In Figure 1, a decrease in t_L will thus shift the contract curve to the 'south-east,' from C to \tilde{C} , implying that the Nash outcome moves from point A_1 to B_1 .

In order to determine how a decrease of the income-tax rate affects the government's tax revenue, we need to be more specific about the characteristics of the production function f and the utility function u . In the subsequent analysis, we assume that output (Y) is iso-elastic in employment:¹⁴

$$(12) \quad Y = f(L) = AL^\alpha, \quad A > 0, \quad 0 < \alpha < 1.$$

By applying the specification (12) to equations (9) and (11), labor-market equilibrium implies

$$(13) \quad \sigma(Q) := \frac{u'(Q)Q}{u(Q) - \bar{u}} = \frac{\mu + (1-\mu)\alpha}{\mu(1-\alpha)},$$

¹⁴In all our models of wage bargaining this yields a constant wage share, which seems to be a quite reasonable characterization of most industrial countries.

where we have used $Q = (1 - t_L)W/P_Q$. The right-hand side of (13) is constant, while the left-hand side, which we denote by $\sigma(Q)$, characterizes the elasticity of excess utility from work with respect to net real income. Condition (13) thus determines the equilibrium value of Q , which is independent of t_L and t_D . We assume that $\sigma'(Q) < 0$, which ensures both existence and uniqueness of labor-market equilibrium.¹⁵ Equation (13) is precisely the characterization of the labor-market equilibrium derived by CREEDY AND McDONALD (1991) for the case of efficient Nash bargains.

Right to Manage

It can be argued that negotiations between firms and the union involve only the wage, leaving the right to manage the level of employment with the firm. If firms behave optimally, this implies that negotiated outcomes will be located on the labor-demand curve. Under the assumption of Nash bargaining, the constrained optimization problem is given by (10) subject to (5). With the specification of production given by (12), the optimal solution yields the equilibrium condition

$$(14) \quad \sigma(Q) = \frac{\mu + (1 - \mu)\alpha}{\mu(1 - \alpha)}.$$

Condition (14) is identical to (13), which implies that both models, *ceteris paribus*, lead to the same equilibrium wage. Note, however, that the level of employment is higher under an efficient contract than for the right-to-manage model (as long as $\mu > 0$).

Monopoly Union

In this setting, the union is in the position to unilaterally determine the wage, but firms still have the right to choose the level of employment. In this case, the monopoly union maximizes its utility (7) under the constraint given by (5), yielding

¹⁵McDONALD AND SOLOW (1981), for example, employ a constant elasticity utility function, which is sufficient for uniqueness.

the equilibrium condition

$$(15) \quad \sigma(Q) = \frac{1}{1 - \alpha}.$$

Since the monopoly union can be viewed as a negotiating party with maximum bargaining power, condition (15) follows from (14) for the special case of $\mu = 1$. From the preceding discussion, it is clear that the monopoly union sets a wage which, *ceteris paribus*, exceeds the negotiated wage in an efficient bargain.

Insider-dominated Union

The insider-dominated union, as it is described by CREEDY AND McDONALD (1991), negotiates a contract with firms, but is only concerned about the wage and not the level of employment. Under simplifying assumptions, this implies that L can be dropped as an argument of (7).¹⁶ As a consequence, the contract curve for efficient bargains coincides with the labor demand curve, so that (unconstrained) Nash bargaining now yields the equilibrium condition

$$(16) \quad \sigma(Q) = \frac{(1 - \mu)\alpha}{\mu(1 - \alpha)}.$$

The Analysis of Labor-Market Equilibrium

In all four models of the labor market, the corresponding equilibrium conditions, (13), (14), (15), or (16), uniquely determine the level of real net wage income and, thereby, workers' composite consumption Q . There are notable differences, though, in the implications of the employment contract on the wage share, generally defined as

$$\omega := \frac{WL}{Y}.$$

For an efficient asymmetric Nash bargaining outcome, the contract wage, given by equation (11), is

$$(17) \quad W = (\mu + (1 - \mu)\alpha) AL^{\alpha-1},$$

¹⁶In the terminology of CREEDY AND McDONALD (1991), this requires the assumption that workers' utility of receiving strike income is the same as their utility of not working.

which implies a wage share of

$$(18) \quad \omega = \mu + (1 - \mu)\alpha.$$

Accordingly, by equation (2), firms' profits are

$$(19) \quad \Pi = (1 - \omega)Y = (1 - \mu)(1 - \alpha)Y.$$

For $\mu > 0$, the wage share ω exceeds α . Note that this is not the case in the other three labor-market models in which equilibrium employment is determined by firms' profit-maximizing labor demand, i.e., where $\omega = \alpha$. In order to keep our analysis as general as possible, we formulate all of the following propositions in terms of the wage share, so that they apply to all four labor-market models discussed above. Hence, with Q determined by (13), (14), (15), or (16), we obtain equilibrium employment for each model from the relationship

$$(20) \quad Q = \frac{(1 - t_L)W}{P_Q} = \frac{(1 - t_L)\omega AL^{\alpha-1}}{P_Q}.$$

For our variety of labor-market models, we are now able to evaluate the qualitative effects of a change in t_L .

Proposition 2 *An increase in the labor-income tax t_L , ceteris paribus, leads to a decrease in aggregate wage income. Moreover, labor-tax revenue will rise with t_L if, and only if, $t_L < 1 - \alpha$.*

Proof: By totally differentiating the labor-market equilibrium condition (13), (14), (15), or (16), one obtains $dQ = 0$ and, from (20), the comparative-static effect of Proposition 1:

$$\frac{\partial L}{\partial t_L} = -\frac{L}{(1 - \alpha)(1 - t_L)} < 0.$$

Next, we determine aggregate wage income $WL = \omega Y$, for which the partial derivative above implies

$$\frac{\partial(WL)}{\partial t_L} = -\frac{\alpha}{(1 - \alpha)(1 - t_L)} WL < 0.$$

Finally, the effect of t_L on labor-tax revenue is

$$\frac{\partial(WLt_L)}{\partial t_L} = \frac{1 - \alpha - t_L}{(1 - \alpha)(1 - t_L)} WL.$$

Hence,

$$\frac{\partial(WLt_L)}{\partial t_L} \begin{matrix} \geq \\ < \end{matrix} 0 \quad \Leftrightarrow \quad t_L \begin{matrix} \leq \\ > \end{matrix} 1 - \alpha.$$

□

Proposition 2 simply characterizes the labor-tax Laffer curve, which has its maximum at $t_L = 1 - \alpha$. In order to understand this result, remember that, for efficient bargains, a change in t_L shifts the contract curve along the Nash curve given by (17), the elasticity of which is

$$-\frac{dW}{dL} \frac{L}{W} = 1 - \alpha.$$

The higher the elasticity of wage adjustment, i.e., the larger $1 - \alpha$ is, the stronger the increasing wage will counteract the negative effect of decreasing employment on aggregate wage income. For equilibrium points on the labor-demand curve (i.e., in the other three labor-market models) the reasoning is analogous: The resulting shifts in W and L now depend on the elasticity of the inverse labor-demand curve which, again, is equal to $1 - \alpha$. If the relative decline of aggregate wage income is less than the relative increase in the income tax rate, i.e. if

$$-\frac{d(WL)}{WL} = \frac{\alpha t_L}{(1 - \alpha)(1 - t_L)} \frac{dt_L}{t_L} < \frac{dt_L}{t_L},$$

then $t_L < 1 - \alpha$ and the government's tax revenues will be increasing in t_L . In this case, the economy is on the "left" (increasing) side of the Laffer curve.

Considering the average labor tax rates in industrial countries, common intuition tells us that most are presumably on the left side of their individual Laffer curves. It is interesting to note that our characterization of efficient Nash bargains offers an additional justification for this view: Without additional country-specific information, one can assume that parties are fairly symmetric in their bargaining abilities. According to (18), in order to obtain a plausible wage share of around 70%, a symmetric Nash bargaining solution ($\mu = 1/2$) would require a production

coefficient of $\alpha = 0.4$. This is not only significantly lower than for a labor-market equilibrium on the labor-demand curve (i.e., where $\omega = \alpha$), but also implies that the Laffer curve has its maximum at $t_L = 0.6$. Hence, $t_L < 1 - \alpha$ appears to be a reasonable starting point for our discussion of a revenue-neutral tax reform.

4. A Revenue-Neutral Ecological Tax Reform

In order to assess the effect of a revenue-neutral tax reform involving both an increase in the environmental tax as well as a decrease in the labor tax, we address this issue within a general-equilibrium setting. In all of this section, we assume that production is specified by a Cobb-Douglas function, as in (12). In addition, we specify private consumption as a Cobb-Douglas function of clean and dirty goods,

$$(21) \quad q(C, D) = C^{1-\delta} D^\delta, \quad 0 < \delta < 1,$$

where δ denotes the expenditure share of dirty goods. The demand for dirty goods is then given by $D = \delta I / (1 + t_D)$, which implies that the price elasticity of D is equal to one. Therefore, according to condition (1), tax revenues are sure to rise with the tax rate t_D . The price index

$$P_Q = \frac{(1 + t_D)^\delta}{\delta^\delta (1 - \delta)^{(1-\delta)}},$$

follows directly from the optimization of private consumption for the Cobb-Douglas specification given in (21).¹⁷

We conduct the analysis for any of the labor-market models discussed in the previous section, so that labor-market equilibrium is characterized by equation (13), (14), (15), or (16). With constant wage and profit shares, and private composite consumption characterized by (21), the consumption of both clean and dirty goods is easily derived for all consuming households (viz., workers and managers). From the public budget constraint (3), one then obtains the equilibrium level of tax revenues

¹⁷Note that optimal consumption implies $C^{1-\delta} = ((1 - \delta)I)^{1-\delta}$ and $((1 + t_D)D)^\delta = (\delta I)^\delta$. By multiplying these expressions, one then obtains $(1 + t_D)^\delta C^{1-\delta} D^\delta = \delta^\delta (1 - \delta)^{1-\delta} I$, which yields the price index $P_Q = I/Q$.

required to finance government consumption

$$(22) \quad G = \left[\omega t_L + (1 - \omega t_L) \frac{\delta t_D}{1 + t_D} \right] AL^\alpha.$$

The term in brackets above is simply the inverse of the general-equilibrium expenditure multiplier; with $t_L \in [0, 1]$, the multiplier is greater than 1.

For any given levels of the environmental tax rate t_D and public spending G , equations (22) and (20), together with (13), (14), (15), or (16), determine the general-equilibrium levels of t_L and L .

Our focus here is on a revenue-neutral tax reform, where an increase in environmental taxes is offset by lowering the labor tax rate, such that government consumption G remains constant. In a general equilibrium, however, there is also the change in employment which must be taken into account. For an economy with no initial environmental tax (i.e., $t_D = 0$) we arrive at the following conclusion.¹⁸

Proposition 3 *The introduction of an environmental tax under a revenue-neutral tax reform leads to a reduction of the labor-tax rate t_L and, simultaneously, to an increase in the level of employment L if, and only if, $t_L < 1 - \alpha$.*

Proof: With $dQ = 0$, total differentiation of (20) with respect to L , t_L , and t_D leads to

$$\underbrace{-(1 - \alpha)(1 - t_L)}_{A_{11} < 0} dL \underbrace{- L}_{A_{12} < 0} dt_L = \underbrace{\frac{(1 - t_L)\delta L}{1 + t_D}}_{B_1 > 0} dt_D,$$

where we have made use of the fact that $dP_Q/dt_D = \delta P_Q/(1 + t_D)$.

Differentiation of (22) with respect to L , t_L , and t_D yields

$$\begin{aligned} & \underbrace{\alpha \left[\omega t_L + (1 - \omega t_L) \frac{\delta t_D}{1 + t_D} \right]}_{A_{21} > 0} dL + \underbrace{\omega \left(1 - \frac{\delta t_D}{1 + t_D} \right) L}_{A_{22} > 0} dt_L \\ & = \underbrace{-(1 - \omega t_L) \frac{\delta}{(1 + t_D)^2} L}_{B_2 < 0} dt_D. \end{aligned}$$

¹⁸In most economies, wide-spread environmental taxes have not yet been established; notable exceptions are Denmark, Norway, and Sweden, and, to a minor extent, the Netherlands and Finland. The case $t_D = 0$, therefore, appears to be a reasonable benchmark for our analysis.

With these two total differentials, one can calculate dL/dt_D and dt_L/dt_D by applying Cramer's rule. The denominator of both terms is given by

$$A_{11}A_{22} - A_{12}A_{21} = L \left[\alpha \frac{\delta t_D}{1+t_D} - \omega(1-\alpha-t_L) \left(1 - \frac{\delta t_D}{1+t_D} \right) \right].$$

For $t_D = 0$, the term in brackets above is negative if, and only if, $t_L < 1 - \alpha$.

Next, consider the numerator of the derivative dL/dt_D :

$$B_1A_{22} - B_2A_{12} = \frac{\delta L^2}{(1+t_D)^2} [\omega(1-\delta)(1-t_L)t_D - (1-\omega)].$$

With $t_D = 0$, this term is unambiguously negative, implying that

$$\frac{dL}{dt_D} = \frac{B_1A_{22} - B_2A_{12}}{A_{11}A_{22} - A_{12}A_{21}} > 0$$

if, and only if, $t_L < 1 - \alpha$.

Finally, the numerator of the derivative dt_L/dt_D is

$$B_2A_{11} - B_1A_{21} = \frac{(1-t_L)\delta L}{(1+t_D)^2} [1 - \alpha - \omega t_L - \alpha t_D (\delta + (1-\delta)\omega t_L)].$$

For $t_D = 0$, this term is positive if, and only if, $t_L < \frac{1-\alpha}{\omega}$. Hence

$$\frac{dt_L}{dt_D} = \frac{B_2A_{11} - B_1A_{21}}{A_{11}A_{22} - A_{12}A_{21}} < 0 \quad \text{for} \quad \begin{cases} t_L < 1 - \alpha < \frac{1-\alpha}{\omega} \\ t_L > \frac{1-\alpha}{\omega} > 1 - \alpha \end{cases}.$$

Consequently, both $dL/dt_D > 0$ and $dt_L/dt_D < 0$ together hold if, and only if, $t_L < 1 - \alpha$.

□

Proposition 3 implies that, if the economy is on the increasing side of its Laffer curve, then the employment dividend of a revenue-neutral environmental tax reform is guaranteed for $t_D = 0$. That is, an environmental tax reform unambiguously boosts employment.

The environmental implications of the revenue-neutral tax reform depend on how the two tax policies affect the consumption behavior of the different households. Clearly, the increase in t_D will provide an incentive for all consuming households to substitute from dirty to clean consumption. But there are also income changes that need to be taken into account.

The tax increase will also cause the price index P_Q to rise, which has a negative effect on consumer real income. In addition, workers have to cope with a decline in their wage, since, according to Proposition 3, the union is now negotiating a higher level of employment. As we have seen, however, this is because the tax on their income declines. In a general equilibrium, there are, thus, various effects that interact in determining net real income.

Nevertheless, as we have seen in the preceding section, the revenue-neutral tax reform succeeds in leaving the net consumer real wage $\frac{(1-t_L)W}{P_Q}$ unaffected, independent of the level of t_L and even of t_D . Hence, any change of t_D and t_L is always offset by an adjustment of the contract wage W .

Due to union behavior, the tax reform lets workers consume the same amount of the composite good as before. However, because of the higher tax rate t_D , their optimal consumption bundle now contains less dirty goods. Indeed, the revenue-neutral tax reform accomplishes the remarkable task of shifting workers' optimal consumption along the household's indifference curve.

Yet, although worker households are individually creating less pollution, higher employment will increase the number of polluting households. In addition, firms' profits rise with employment according to (19); if this is not compensated by the higher price index, then the manager household will experience a rise in its real income which it spends on both clean as well as dirty goods. If we take all of these effects into account, we arrive at the following outcome of an environmental policy.

Proposition 4 *The introduction of an environmental tax under a revenue-neutral tax reform leads to an increase in the aggregate consumption of dirty goods and, consequently, to a decline in environmental quality if*

$$(1 - \alpha) \left(1 - \frac{1 - \omega}{\omega} \frac{\alpha}{1 - \alpha} \delta \right) < t_L < (1 - \alpha).$$

Proof: Consider first the manager household whose consumption of dirty goods is given by

$$D_M = (1 - \omega) \frac{\delta}{1 + t_D} A L^\alpha.$$

By totally differentiating this with respect to t_D , one obtains

$$\frac{dD_M}{dt_D} = D_M \left[\frac{\alpha}{L} \frac{dL}{dt_D} - \frac{1}{1+t_D} \right].$$

From the proof of Proposition 3, we know

$$\left. \frac{dL}{dt_D} \right|_{t_D=0} = \frac{1-\omega}{\omega} \frac{\delta L}{1-\alpha-t_L}.$$

This implies that

$$\left. \frac{dD_M}{dt_D} \right|_{t_D=0} > 0 \quad \Leftrightarrow \quad \frac{1-\omega}{\omega} \frac{\alpha \delta}{1-\alpha-t_L} > 1,$$

which holds only if

$$(1-\alpha) \left(1 - \frac{1-\omega}{\omega} \frac{\alpha}{1-\alpha} \delta \right) < t_L < 1-\alpha.$$

Next, consider the aggregate consumption of dirty goods by all worker households:

$$D_L L = \omega \frac{\delta}{1+t_D} (1-t_L) A L^\alpha.$$

Total differentiation with respect to t_D yields

$$\frac{d(D_L L)}{dt_D} = D_L L \left[\frac{\alpha}{L} \frac{dL}{dt_D} - \frac{1}{1+t_D} - \frac{1}{1-t_L} \frac{dt_L}{dt_D} \right].$$

For $t_D = 0$, $dt_L/dt_D < 0$ if $t_L < 1-\alpha$. This implies that, for $d(D_L L)/dt_D$ to be positive, it is sufficient that dD_M/dt_D is positive. \square

If households' expenditure share for dirty goods, δ , is sufficiently high, then a high income-tax rate, t_L , will cause a revenue-neutral environmental tax to backfire, provided the economy is on the left side of the Laffer curve. Indeed, as long as there is any consumption of dirty goods ($\delta > 0$), this scenario is possible; and it is not even an exceptional case, since excessive pollution and high taxes are precisely the conditions under which an environmental tax reform is worth discussing in the first place.¹⁹

¹⁹Note that it would be a mistake to interpret δ as a policy variable. Of course, if green taxes are limited to only a few goods, then governments could boast of reaping a double dividend. But environmentalists should not applaud, since households would mostly be substituting from taxed dirty consumption to untaxed dirty consumption.

The higher δ is, the lower t_L must be for an environmental improvement under a revenue-neutral tax reform. Assume, therefore, that the environmental tax is introduced at a lower labor-tax, where $t_L < (1 - \alpha) \left(1 - \frac{1-\omega}{\omega} \frac{\alpha}{1-\alpha} \delta\right)$, such that the condition of Proposition 4 is not fulfilled. In that case $dD_M/dt_D < 0$. This implies that every consuming household will now reduce its consumption of dirty goods, when an environmental tax is raised. The interesting question then is whether it is still possible, under plausible conditions, that the employment effect is strong enough to increase aggregate pollution $D_L L + D_M$. Figure 2 shows the effect of the income tax t_L on the marginal change of pollution $d(D_L L + D_M)/dt_D$ when environmental taxation is introduced at different levels of δ .

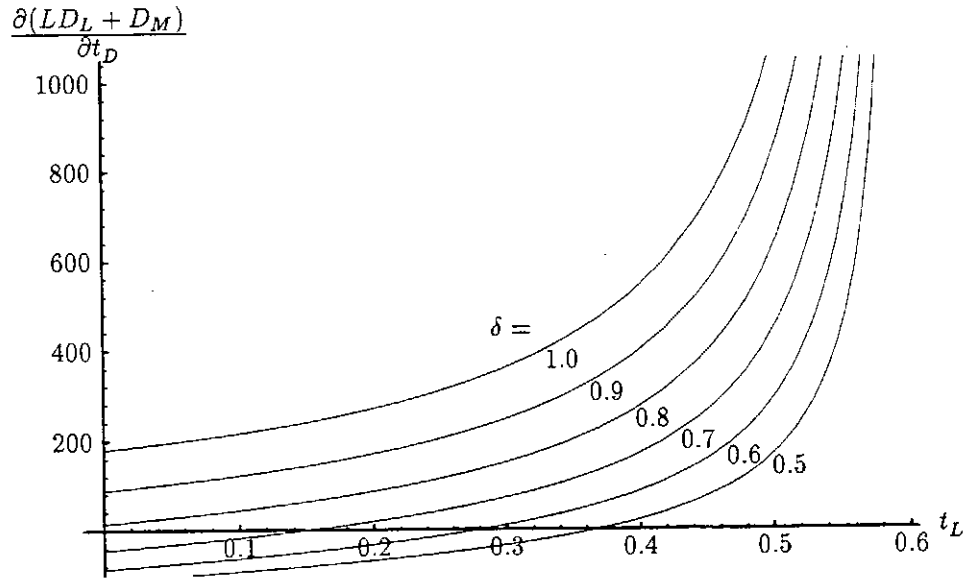


Figure 2: Marginal effect of environmental taxation

For a given value of δ , the marginal change of pollution is increasing in t_L , and it becomes positive for a sufficiently high labor-income tax rate $t_L < 1 - \alpha$. Moreover, as δ rises, the range of t_L -values for which pollution increases widens. Indeed, as we show in the following proposition, if households' expenditure share for dirty goods exceeds a critical level, then a revenue-neutral environmental tax reform will backfire for any income-tax rate, t_L , on the increasing branch of the Laffer curve.

Proposition 5 *The introduction of an environmental tax under a revenue-neutral tax reform will lead to an increase in the aggregate consumption of dirty goods and, consequently, to a decline in environmental quality, for any $0 < t_L < 1 - \alpha$, if*

$$\delta \geq \bar{\delta} := \frac{\omega(1 - \alpha)}{\alpha + \omega - 2\alpha\omega}.$$

Proof: From the proof of Proposition 4 one can derive

$$\left. \frac{d(D_L L + D_M)}{dt_D} \right|_{t_D=0} = \frac{\delta A L^\alpha}{\omega(1 - \alpha - t_L)} [\alpha\delta(1 - \omega) - \omega(1 - \delta)(1 - \omega t_L)(1 - \alpha - t_L)].$$

Clearly, this expression is increasing in t_L for $t_L < 1 - \alpha$. Moreover, it is strictly positive for any $0 < t_L < 1 - \alpha$ if

$$\begin{aligned} \left. \frac{d(D_L L + D_M)}{dt_D} \right|_{\substack{t_D=0 \\ t_L=0}} &\geq 0 \\ \Leftrightarrow \quad \alpha\delta(1 - \omega) &\geq \omega(1 - \delta)(1 - \alpha) \\ \Leftrightarrow \quad \delta &\geq \frac{\omega(1 - \alpha)}{\alpha + \omega - 2\alpha\omega} =: \bar{\delta}. \end{aligned}$$

□

Proposition 5 reveals that the critical value for the households' expenditure share $\bar{\delta}$ is determined by the relationship between the wage share ω and the production coefficient α , which are both parameters of the labor market. In Figure 2, the critical value $\bar{\delta}$ is slightly less than 0.8. More generally, we can state that

$$\bar{\delta} \geq \frac{1}{2} \quad \Leftrightarrow \quad \omega \geq \alpha.$$

Hence, for an economy on the left side of its Laffer curve, the environmental tax reform is more likely to fail ($\delta \geq \bar{\delta}$) when the labor-market equilibrium is characterized by a contract on the labor-demand curve, because then $\bar{\delta} = 1/2$.

The results of Propositions 4 and 5 apply to the introduction of an environmental tax, i.e., when $t_D = 0$. In order to see whether the general-equilibrium implications of the revenue-neutral tax reform are also relevant for $t_D > 0$, we look at the numerical outcome for different levels of t_D . The parameter specifications for the model are given in Table 1.

$\alpha = 0.40$	$\mu = 0.5$	$\delta = 0.75$
$A = 100$	$G = 125$	$\bar{u} = 1$

Table 1: Parameter specifications for the general-equilibrium model

With $\alpha = 0.40$, the wage share under symmetric Nash bargaining (i.e. $\mu = 0.5$) is $(1 + \alpha)/2 = 0.70$, which approximates the values of most industrial countries. Moreover, according to Proposition 2, the peak of the economy's Laffer curve is at $t_L = 0.60$. Households spend 75% of their income on dirty goods, so that pollution is a significant problem. However, $\delta < 0.78 = \bar{\delta}$, which is the critical level for Proposition 5, and one can easily check that the condition for Proposition 4 is only met if $0.47 < t_L < 0.60$. We can, therefore, test the robustness of our conclusions when the conditions for Propositions 4 and 5 are both not satisfied. The multiplicative constant A determines the scale of the economy, so that it also restricts the feasible range for G , which we choose accordingly. Finally, for convenience, we specify $u(Q) = Q$ and normalize \bar{u} to unity. With these parameter values, we solve the general-equilibrium model and vary the tax on dirty goods parametrically. For $t_D = 0$, $t_D = 0.10$, and $t_D = 0.20$, the results are displayed in Table 2.

t_D	t_L	L	$t_L W L$	$\frac{(1-t_L)W}{P_Q}$	$\frac{\Pi}{P_Q}$	D_L	D_M	$LD_L + D_M$
0	0.28	107.15	125.00	1.75	110.89	2.30	145.94	392.72
0.10	0.18	116.61	85.05	1.75	106.79	2.25	137.24	399.47
0.20	0.09	124.09	44.59	1.75	102.57	2.20	128.97	402.02

Table 2: General-equilibrium implications of a revenue-neutral tax reform

Even for $t_D > 0$, one can see that t_L is decreasing and L is increasing under the environmental tax reform. Note that the values for t_L are not very high; in particular, the condition for Proposition 4 is not satisfied. In addition, the ratio of government spending G to national product ($Y = AL^\alpha$) is slightly less than 20%, which also provides empirical support from national income accounts for the calibration of the

general-equilibrium model. Since the economy is on the left side of the Laffer curve, income-tax revenue declines. The fifth column, shows a constant net real wage for any level of t_D . Although profits, Π , rise with L , the increase in the price index, P_Q , suffices to make real profits fall. With a constant net real wage income and decreasing real profits, both D_L and D_M fall as a result of environmental taxation. The most important aspect of this ecological policy is, however, presented in the last column, which shows that aggregate consumption of dirty goods rises. Hence, environmental quality decreases when a revenue-neutral tax reform is enforced.

5. Conclusion

The purpose of this paper was to analyze the environmental as well as the economic implications of a revenue-neutral ecological tax reform within a general-equilibrium setting. While most of the political and theoretical discussion of a double dividend assesses the arguments for or against a positive employment effect, we argue that it is the impact on the environment which one should worry about.

We found for a variety of qualitatively different labor-market scenarios that a revenue-neutral environmental tax reform induces higher employment in a non-competitive labor market, if the economy is on the increasing side of its Laffer curve. As a consequence, the number of polluting households increases. Since part of labor income is spent on dirty goods while leisure, in contrast, is clean, labor indirectly harms the environment. A rise in employment is, therefore, undesirable from an environmental point of view. Consequently, the occurrence of the employment dividend endangers the environmental dividend. Provided that the expenditure share of dirty consumption is large and the distortionary tax rate on income is high – both of which are plausible conditions for an environmental tax reform – the proposed environmental policy will lead to higher pollution, even if the higher environmental tax encourages every consuming household to reduce its wasteful consumption.

Our analysis thus illustrates that, if the conditions for the employment dividend of environmental taxation are satisfied, the environmental dividend is likely to be lost. There is no trade-off that can be exploited politically. It is just when a

revenue-neutral environmental tax reform is successful economically, that it cannot be recommended as an environmental policy.

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